KAPITAŁ LUDZKI
NARODOWA STRATEGIA SPÓJNOŚCI

UNIWERSYTET GDAŃSKI

UNIA EUROPEJSKA
EUROPEJSKI
FUNDUSZ SPOŁECZNY

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Course title **Information Theory**	**ECTS code** 13.2.0422

Name of unit administrating study
Department of Mathematics, Physics and Informatics

Studies

Faculty	**Field of study/ phd studies/doctoral school/postgraduate studies**	**Type**	**Form**
Quantum Information Technology	MSc studies	stationary	

Teaching staff
Dr hab. Karol Horodecki, prof. UG

Forms of classes, the realization and number of hours

A. Forms of classes, in accordance with the UG Rector's regulations
Lecture, auditory exercises

B. The realization of activities
classes in the teaching room of the University of Gdańsk
blended learning

C. Number of hours
Lecture: 30, exercises: 30

ECTS credits

Total: 5 ECTS including:
30 h of lecture – 1 ECTS point;
30 h of exercises – 1 ECTS point;
30 h of consultation – 1 ECTS point;
60 h of student's own work - 2 ECTS points.

The academic cycle
According to study program

Type of course
mandatory

Language of instruction
English

Teaching methods
problem lecture
lecture with multimedia presentation

discussion
case analysis
problem solving

Form and method of assessment and basic criteria for evaluation or examination requirements

A. Final evaluation, in accordance with the UG study regulations
Exam
Credit with grade

B. Assessment methods
Exercises: tests
Lecture: written exam: 3 groups of issues out of 15 covered in the lecture, described correctly in minimum 50%.

C. The basic criteria for evaluation or exam requirements
Exercises:
90% of the final mark : 2 written colloquia during the semester.
10% of the final mark are due to activity of the student during classes.
Lecture:
3 groups of issues out of 15 covered in the lecture, described correctly in minimum 50%.

D. Method of verification of the established effects of education

established effect of education	exam	activity	tests
W01	+	+	+
W02	-	+	+

U01	-	+	+
U02	-	+	+

Required courses and introductory requirements

A. Formal requirements

Completion of the course "probability theory" and/or statistical physics is required.

B. Prerequisites

Basic knowledge of mathematics at high school level is required.

Aims of education

The student will acquire basic knowledge in the field of application of the main concepts of information theory such as entropy, mutual information or relative entropy and their properties. He will also learn the capacities of communication channels and methods of estimating them. Acquiring this knowledge will result in understanding of the possibilities and limitations of communication as well as will provide an introduction to other courses of quantum information theory. The student will be able to apply the knowledge learned in whatever context it can be used, including physics, statistics and cryptography.

Course contents

The course contents includes presentation of the following concepts (lecture and exercises will be devoted to the same topics):

- **Shannon entropy function, its interpretation and properties,**
- **Entropy functions of many variables, including conditional entropy, mutual information, relative entropy, conditional mutual information and their properties, including data processing inequality and the chain principle for conditional mutual information**
- **"Asymptotic Equipartition Property" theorem, compression codes (including Huffman's), Lempel-Zif compression algorithm**
- **Error correction codes (Huffman, CSS, other line codes)**
- **The concept of typical and total typical sequences, Shannon's theorem on the capacity of a communication channel, random code technique**
- **Capacities of selected communication channels (among others, broadcast channel, multiple access channel, erasure channel) and Slepian-Wolf theorem on joint coding**
- **Interpretation of relative entropy in the context of betting**
- **Kolmogorov complexity and Kraft and Mc Millan inequality**
- **The use of IT in cryptography (secure key agreement) including the Csisar & Koerner theorem and the protocol increasing security by means of two-way communication by U. Maurer and non-increasing (so-called monotonous) security functions.**
- **Application of IT in quantum communication: von-Neumann entropy versus Shannon entropy similarities and differences; quantum conditional entropy versus Shannon's conditional entropy - comparison.**

Bibliography of literature

A. Literature required to pass the course

- **E. Shannon, W. Weaver " The Mathematical Theory of Communication"**
- **Thomas M. Cover, Joy A. Thomas "Elements of Information theory"**
- **R. W. Yeung "A First Course in Information Theory"**
- **chapters of M. Nielsen, I. Chuang „Quantum Information and Computation" concerning IT**

B. Extracurricular readings

- **other chapters of M. Nielsen, I. Chuang „Quantum Information and Computation"**

The learning outcomes (for the field of study and specialization) *K_W01* *Student has extensive knowledge of general physics and advanced knowledge in the area of quantum information theory; knows the history of the development of quantum information theory and its importance for the progress of*	**Knowledge** W01: Student can define basic notions including entropy, mutual information, code, channel capacity, relative entropy, Kolmogorov complexity etc. (K_W01) W02 Student knows the proofs of the main facts such as Asymptotic Equipartition Property, Shanonn's theorem etc., as well as knows basic methods such as compression algorithms (K_W02)
	Skills U01 Student is proving certain information-theoretic properties of a complex systems such as channels and their capacities, and is interpreting the results (K_U01) U02

science, world cognition and social development *K_W02* *Student has in-depth knowledge of advanced mathematics, mathematical and computer methods necessary to solve physical problems of medium complexity and advanced in the area of quantum information and its technological aspects* *W_W06* *Student has knowledge of the current trends in the development of physics, in particular within the quantum information theory* *K_U01* *Student can apply mathematical knowledge to formulating, analyzing and solving problems related to information theory*	The student is able to apply introduced methods and concepts in various context of information theory including other fields (such as physics, statistics or cryptography) (K_U01)
	Social competence
Contact **khorodec@inf.ug.edu.pl**	